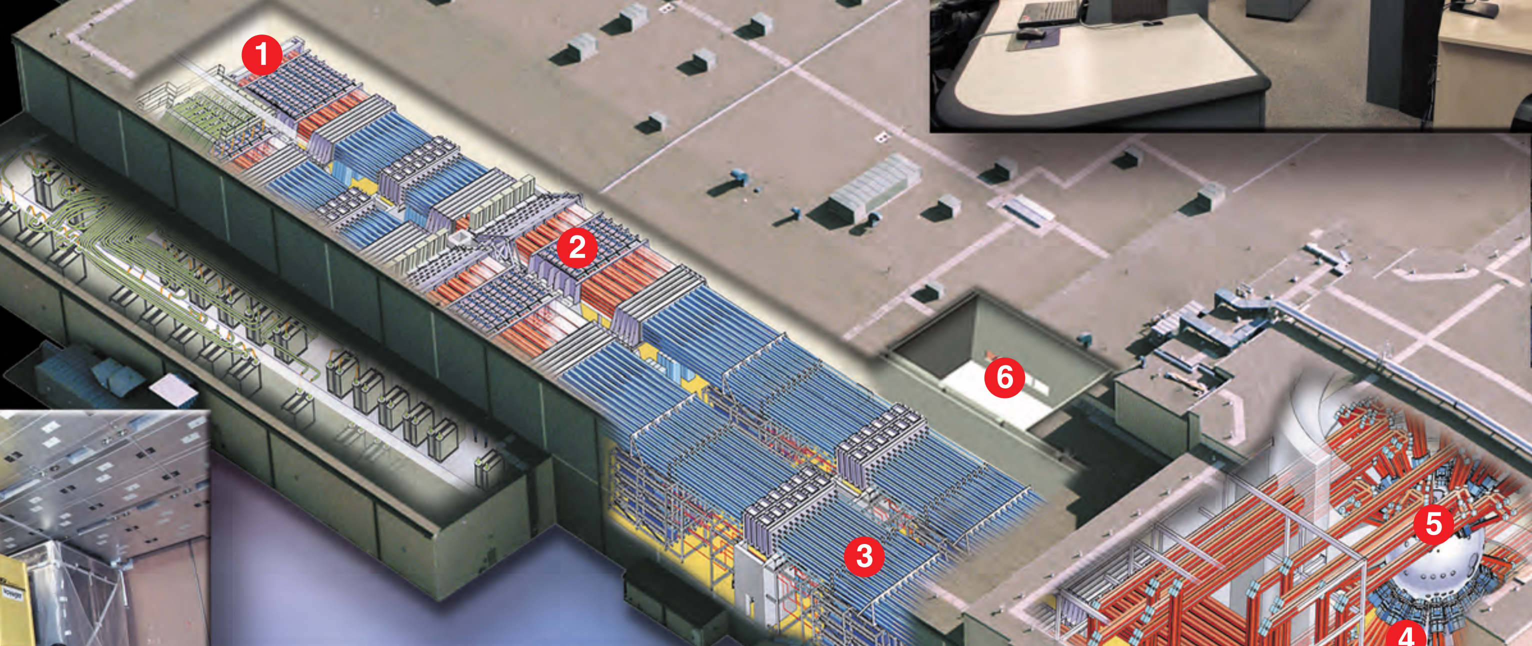
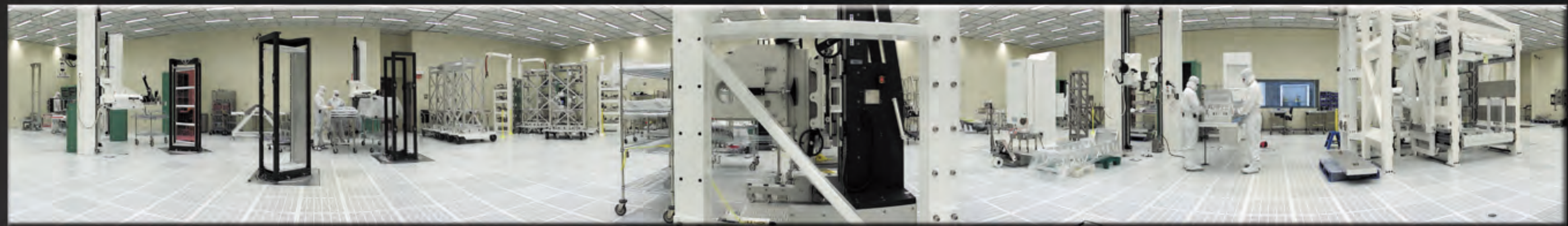
NATIONAL IGNITION FACILITY

THE POWER OF LIGHT

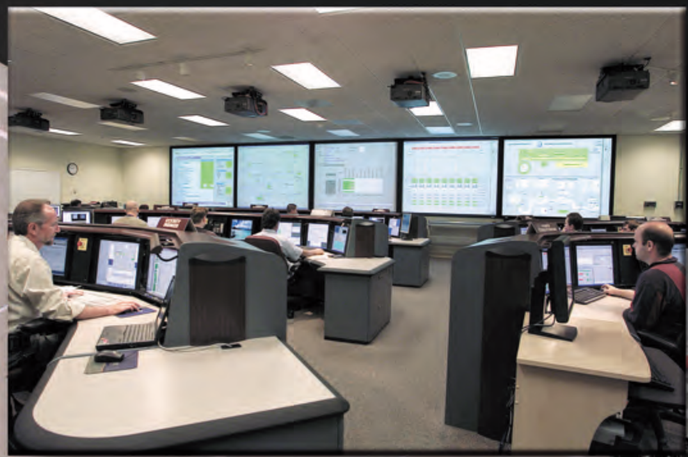
The National Ignition Facility

Spanning the length of two football fields, NIF houses 192 laser beams in two bays in precision-aligned and environmentally controlled conditions. The aerial photograph of the NIF facility has been combined with a computer-generated model revealing one bay of the laser system. NIF delivered its first laser light to the target chamber in 2003, and all 192 laser beams will be operational in 2009. Science experiments already are being conducted on NIF, with increasing capability for inertial fusion and high energy density research becoming available throughout this time. Follow the progress of NIF on our Website: lasers.llnl.gov.

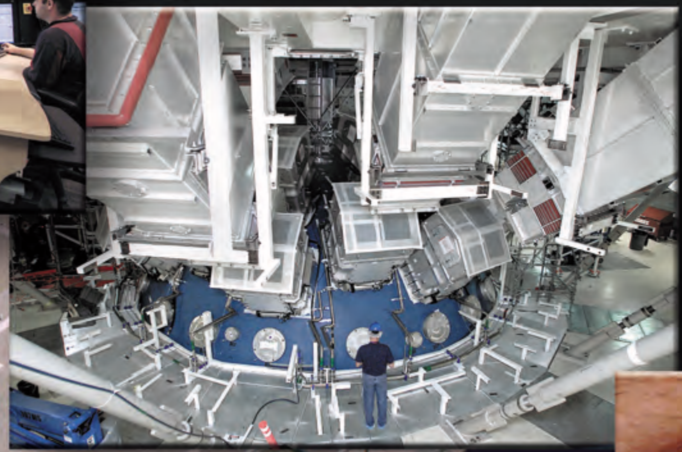




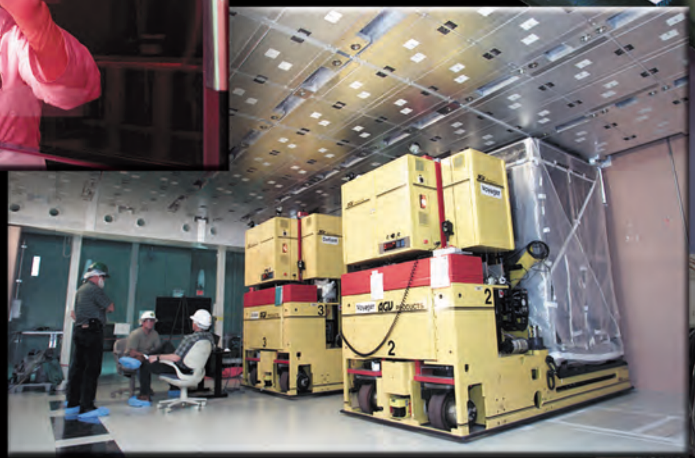
7 A 360-degree panorama of the Class 100 clean room facility in the Optics Assembly



6 The NIF Control Room controls all aspects of the laser system and target experiments.



5 At the center of the 10-meter-diameter target chamber, the 192 ultraviolet laser beams converge on the target.



1 The NIF laser contains more than 3,000 pieces of amplifier glass. They are cleaned and assembled into modules before automated guided vehicles install them into the laser system.

2 The cable plant delivers electrical power to the flashlamps in the amplifier system.

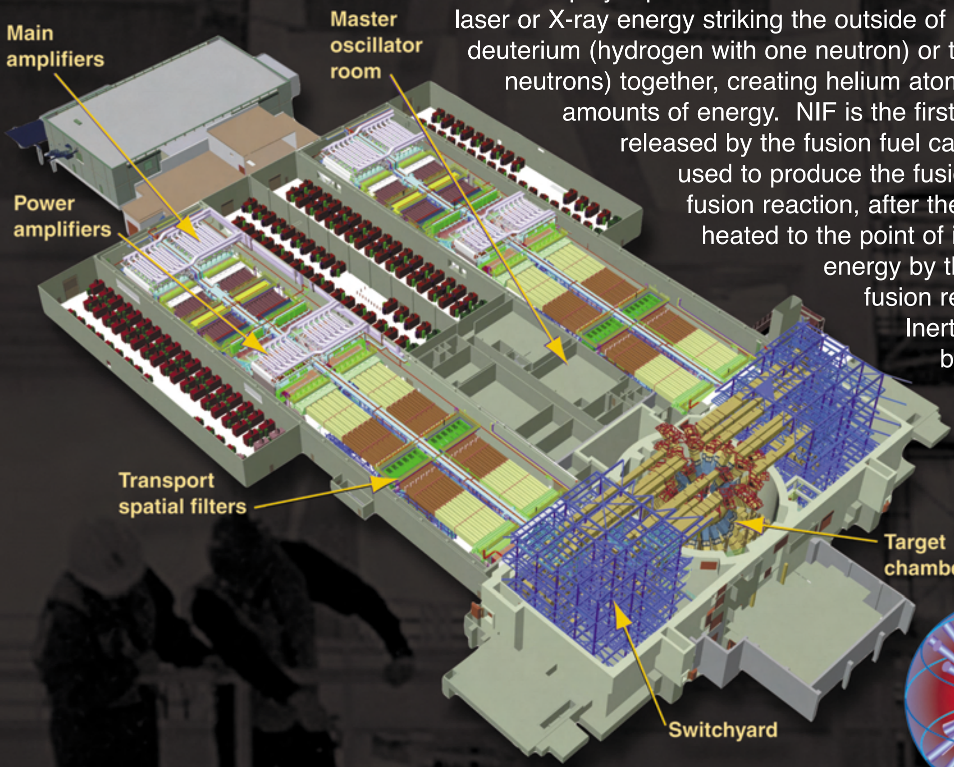
3 Beam tubes transport laser light to the target chamber.

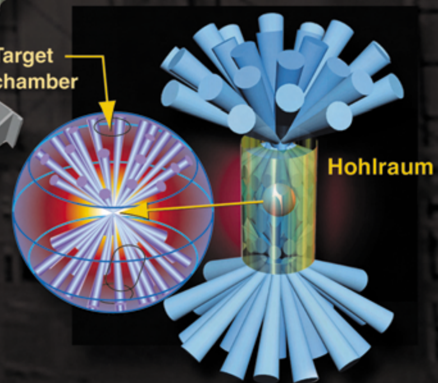
4 Slices of giant crystals convert the infrared lasers to ultraviolet light before the beams enter the target chamber.

Inertial Confinement Fusion: How to Make a Star

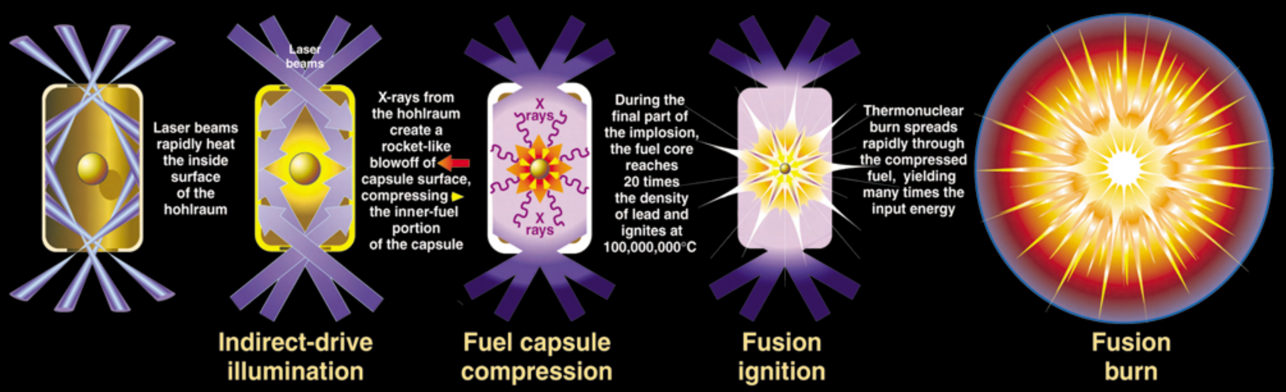
Inside the 30-foot-wide target chamber, a gold cylinder the size of a dime receives energy from all 192 laser beams simultaneously: about 1.8 million joules over a few billionths of a second (about 500 trillion watts, which is nearly 1,000 times the power generated in the United States over the same time period). This cylinder then produces X-rays that compress and heat a fusion capsule inside the cylinder to temperatures and pressures approaching those in a nuclear explosion or in the sun, igniting the fusion fuel in a self-sustaining reaction and creating a miniature star in the laboratory.

NIF will employ a process called inertial confinement fusion, in which either laser or X-ray energy striking the outside of the target fuses atoms of deuterium (hydrogen with one neutron) or tritium (hydrogen with two neutrons) together, creating helium atoms, extra neutrons and large amounts of energy. NIF is the first laser in which the energy released by the fusion fuel can exceed the laser energy used to produce the fusion reaction. In a self-sustaining fusion reaction, after the capsule is compressed and heated to the point of ignition, the release of fusion energy by the fuel drives the rest of the fusion reactions until the fuel is spent. Inertial confinement fusion is limited by the amount of fusion fuel in the tiny capsule, and is therefore totally controllable.

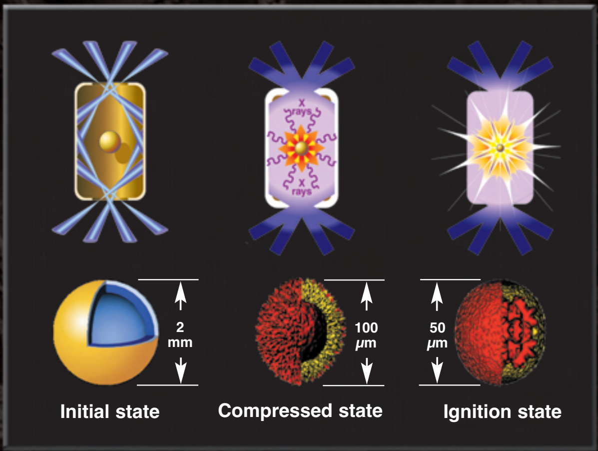




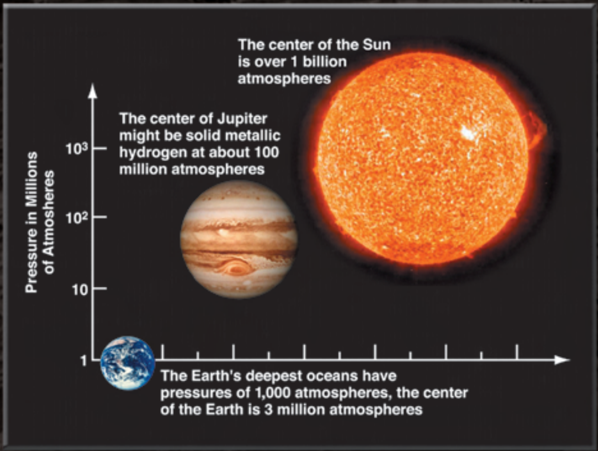
The Fusion Process



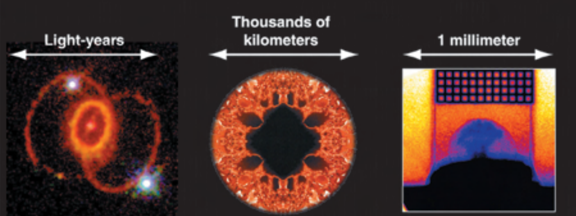
NIF Science *Understanding the Universe*



Sophisticated computer models are used to show how NIF laser beams compress and heat an ignition target to the conditions for nuclear fusion to occur. The figure on the left shows the fusion capsule at its initial state. In the middle figure, computer simulations show the capsule is being compressed and its implosion velocity is greatest; the density of the fuel is six times the density of lead. The rippled surface is caused by amplification of slight imperfections in the machining of the capsule. The simulation on the right shows the fusion capsule at ignition time. At this point the capsule is compressed to a diameter less than that of a human hair and the density of the fuel is 20 times the density of lead. The compression heats the capsule to tens of millions of degrees–the conditions are now right for fusion to begin!



When materials are subjected to high pressures they compress, which can significantly alter their material properties. For example, compressing soft graphite can rearrange the material's crystalline structure to create an extremely hard diamond. Scientists use a number of tools to compress materials, from explosives, gas guns and diamond anvil cells to high-energy lasers. Current high-pressure facilities cannot achieve pressures greater than a few tens of millions of atmospheres. NIF significantly expands the regimes of high energy density physics that can be reached in the laboratory. NIF laser beams will shock material samples to extreme pressures and temperatures, producing conditions similar to those at the center of stars and giant planets. NIF ignition can achieve pressures of tens of billions of atmospheres in material – greater than the pressure at the center of the sun.



Supernova 1987a allows the real-time study of astrophysical phenomena, such as the violent collision of radiating shock waves with tenuous gases that make up the intersteller medium.

This computer simulation shows the extreme turbulence inside Supernova 1987a at the time it exploded. NIF experiments can simulate the complex mixing of the different layers inside a star at the time it becomes a supernova.

This NIF experiment recreates the turbulent conditions–on a small scale–observed in supernovae by driving a supersonic jet of aluminum into a low-density foam. This data can be used to validate and improve computer models.

Scientists are using NIF to simulate extreme astrophysical environments in the laboratory. For example, NIF can create conditions in materials that mimic those occurring in a violent supernova explosion. In a supernova, a star's nuclear engine has burned out and the star consists of onion-like layers of different atomic elements with different densities. Gravitational forces collapse the star, forcing the different layers to mix in an unstable fashion. This process is called a Rayleigh-Taylor hydrodynamic instability, and can be modeled on NIF in small targets and scaled to stellar dimensions. Data from NIF experiments like these can help scientists to better understand how stars work.

Lawrence Livermore National Laboratory

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Our Missions

Energy for the Future
NIF is designed to demonstrate fusion ignition and energy gain — two key milestones along the path to limitless fusion power production.

National Security
Data from NIF experiments will help scientists understand the complex physics of nuclear weapons, ensuring the safety and reliability of our strategic deterrent.

Understanding the Universe
NIF experiments can create immense pressures and temperatures similar to those in stars and supernovae. These experiments bring the study of astrophysical phenomena, materials science and nuclear physics into a controlled laboratory setting.

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